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PRELIMINARY REPORT UPON THE INFESTATION AND GENERAL STATUS OF THE EUROPEAN CORN BORER IN WESTERN NEW YORK

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INTRODUCTION

In order to estimate the progress of infestation by the European corn borer (*Pyrausta nubilalis* Hübn.) in that portion of New York State bordering Lake Erie, where the insect was first found in 1919, very detailed field surveys have been made from year to year. At various times requests have been received from representatives of the New York State Department of Agriculture, and from corn growers residing in the infested portions of the State, for information concerning the history of the infestation in that portion of the infested area in which annual detailed observations have been made. Similar requests have been received from representatives of corn-processing companies in western New York. At meetings held at various points in Pennsylvania and Connecticut, many requests for information concerning the western New York infestation have been received. The purpose of this circular is primarily to furnish such interested persons with information relating to the annual changes in intensity of corn-borer infestation in the western New York area.

These surveys were first confined to the town of Hanover in Chautauqua County, and certain fields located on the Cattaraugus Indian Reservation in Brant Town, Erie County, which comprised at that time the most heavily infested area in western New York. Gradually, as this area was extended, the territory covered by the survey was increased until, in 1927, representative fields were selected in the towns of Westfield, Portland, Pomfret, Sheridan, Dunkirk,

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and Hanover in Chautauqua County, and in the town of Brant in Erie County.

Representative fields in this area were selected, and the same or near-by fields, whenever it was possible, were used each year. In selecting the farms on which observations were to be made, the approximate locations of such farms were first indicated on maps in such a way that all sections of the area under observation were represented. Each location was then visited and a near-by farm selected as an observation point. The same locations were used in following years, except when a grower's failure to plant corn necessitated the substitution of an adjoining farm. Because of the relative importance of such field records, it is believed necessary to go into the manner of making such surveys in detail, as such information must form the basis for the selection of those types and varieties of corn that produce the best yields under corn-borer conditions, the determination of the effect of time of planting upon resultant corn-borer infestation, and the comparative increase or decrease of infestation from year to year in this particular section. This farming section is characteristic of all areas bordering the southeastern shore of Lake Erie.

The surveys conducted from 1920 to 1923, inclusive, were made primarily to determine the spread and increase or decrease of borer population in the heavily infested area, and to determine the effectiveness of the experimental clean-up which was conducted by the United States Department of Agriculture in the fall of 1920 and spring of 1921. In the spring of 1924, in view of the relatively permanent importance of such detailed records, a very comprehensive, detailed study of these individual fields was made which enlarged somewhat upon the previous method of making such counts. Parts of some of the summary tables and figures showing comparative infestation in this area have been published previously,[2] but no complete detailed data showing how such surveys were carried on have been assembled for general use.

HISTORY OF THE WESTERN NEW YORK INFESTATION

The first infestation by the European corn borer was discovered in the western New York area in 1919. On July 1, 1920, there were 469 square miles of infested land in the Lake Erie section, practically all in New York (only one township—Girard, in Erie County—in Pennsylvania), where a very slight infestation was found. This area in New York comprised the towns of Cheektowaga, Hamburg, Eden, Evans, Brant, North Collins, and Collins in Erie County, and Pomfret, Sheridan, Hanover, Perrysburg, Dayton, and Persia in Chautauqua County.

Because of this spread of infestation, a laboratory was established at Silver Creek, N. Y., in 1920, although some observations were

[2] CAFFREY, D. J., and WORTHLEY, L. H. THE EUROPEAN CORN BORER AND ITS CONTROL. U. S. Dept. Agr. Farmers' Bul. 1294: 14, 26. 1922.

——— and WORTHLEY, L. H. A PROGRESS REPORT ON THE INVESTIGATIONS OF THE EUROPEAN CORN BORER. U. S. Dept. Agr. Bul. 1476: 48. 1927.

WORTHLEY, L. H., and CAFFREY, D. J. SPREAD AND INFESTATION BY THE EUROPEAN CORN BORER DURING 1926. U. S. Dept. Agr. Misc. Circ. 104: 4–5. 1927.

——— and CAFFREY, D. J. SCOUTING, QUARANTINE, AND CONTROL FOR THE EUROPEAN CORN BORER, 1917–1926. U. S. Dept. Agr. Tech. Bul. 53: 134–137. 1927.

made by field men previous to this time. Owing to the importance of the sweet-corn crop in this area, and particularly since this isolated infestation was some 300 miles west of the nearest eastern infestation, which was in the vicinity of Schenectady, N. Y., an attempt was made to greatly reduce the numbers of the insect by carrying on a very intensive clean-up campaign in the most heavily infested district. The object of this experiment was twofold; (1) to endeavor to exterminate the insect in this clean-up district if possible, or at least to greatly reduce its numbers and thus cut down the danger of increased spread to areas south and west, and (2) to ascertain the feasibility of further clean-up operations over larger areas. The most severe infestation covered a block of about 25 square miles located in Hanover Town and in the vicinity of Silver Creek. This undertaking was carried on during the fall of 1920 and the spring of 1921. The cooperation of the farmer was requested, yet owing to the fact that stalks and stubble were either burned or steamed, largely by use of special equipment, government labor and equipment were used almost entirely. In spite of this clean-up, the infestation increased during the following season, although many fields showed marked decreases. The increase in 1921 was probably caused by some outside agency, possibly by the flight of moths from Canada and the near-by Indian reservation where no clean-up work was done.

Owing to the fact that it was found impossible to eradicate the borer, even by very thorough clean-up operations, and owing to the gradual increase in the numbers of the insect in the area, the planting of corn was gradually reduced until 1926, when commercial losses in both field and sweet corn became quite general. This loss was greater in varieties of sweet corn because the damage affected its sale for human consumption; yet similar yield losses occurred in field varieties. Nearly one-half of the corn acreage in this area is ordinarily devoted to sweet corn, and a very large percentage of this is used by local canning factories.

Not only had the infestation increased, but the insect had gradually spread, and in 1926 (after the completion of scouting work) practically the whole of New York State and nearly one-half of the State of Pennsylvania were found to have become infested. The infested area had also moved westward along the shores of Lake Erie to include parts of Ohio, Michigan, and Indiana. Because of this rapid spread and the possibility of severe infestation, such as that in Canadian areas which caused nearly total loss of crops, the various State departments, backed by agricultural interests, requested Congress to furnish adequate funds to thoroughly clean up these areas, not with the idea of extermination but in an endeavor to greatly reduce the numbers of the pest and to delay its spread to the great corn areas in the Middle West. Congress responded by providing a fund of $10,000,000 for the work. Previous research and control experiments had definitely shown the advantages of certain control measures, particularly the clean plowing under of crop refuse, and other good farm practices, as control agencies. It was early recognized that, to be successful, control measures must be practical and be readily adaptable to good farming methods. In New York State, 32 towns, comprising the most heavily infested area in the western

section of the State, were included in this large-scale clean-up. This area included the seven towns which were covered by the annual infestation survey. The success of this work accounts directly for the decrease in numbers of the insect in this area in 1927, inasmuch as an increase in infestation was found in those areas of New York not included in this clean-up project.

METHOD OF MAKING INFESTATION RECORDS

During the period 1921 to 1923, inclusive, no accurate examination was made to determine the total number of plants in each field under observation, a fixed, estimated number of stalks per acre being used in all cases. In 1924 it became apparent that more accurate figures should be obtained because of the large variation in the number of plants per acre, depending upon the type and variety of corn grown, as well as the distance between rows and the stand of corn at the time the examinations were made. For this reason each field was considered individually, and more accurate estimates were made as described in paragraphs that follow. From 1921 to 1924 no definite method was used in the selection of plants in each field to be examined, except that observations were made in such a way as to be representative of all parts of each field under observation. During the period 1925 to 1929 a very definite system of plant selection was used in relation to the field as a unit, and this is described in the following paragraphs. With possibly the two exceptions previously mentioned, the same method was followed in making field counts as has been used since 1921.

CORN PLANT

Accurate information was secured from the grower relative to the type and variety of corn planted and the exact planting date. Various methods have been employed in checking the acreage carefully. In some cases fields were actually measured by tape, but it was found that a very high degree of accuracy was obtained by the experienced observer in pacing their dimensions. Where corn was drilled, the distance apart of rows gave one dimension very accurately. In many fields the corn was check-rowed, and a very close figure was obtained by measuring the distance between the rows and the hills in the row, then counting the total rows and the total plants per row, the plants in two or more rows being counted to obtain an average.

In making plant examinations it was the practice, wherever possible, to select an average of 100 plants per acre in the field under observation, with a maximum of 500 plants in any one field, an equal number of consecutive plants being selected in the center of each quarter and in the center of the field. During the seasons of 1924 and 1925, however, a minimum of 100 plants per acre were examined, regardless of the size of the planting, the same method of selection being used as in other years.

In making examinations of plants for infestation, the first plant was selected at random in that section of the field under observation, and the total number of plants to be examined in that section taken consecutively in that row. In making such plant examinations to determine those infested, it was impossible to dissect all plants ob-

served; consequently observations for infestation were made without actual dissection, each plant showing evidence of infestation being considered infested. In some cases it was found necessary to remove the leaves from plants in order to detect frass or other signs of infestation. A minimum of 10 infested plants were dissected in order to obtain the average number of larvae per infested plant. Inasmuch as fields under observation were of various acreages, it was necessary, as a means of comparison, to compute the weighted averages (in order that all fields might have the same value) of the percentage of plants infested and the larval population of each field under observation. These averages were obtained by carefully estimating the total number of plants in all fields examined and the total number of larvae in these same fields.

CORN STUBBLE

The method of making stubble examinations was similar to that used in making plant examinations, except that a minimum of 100 stubs per acre were actually dissected. In averaging the height of stubble in each field, the average of at least 10 carefully measured stubs was used. Only those stubs actually containing larvae were considered infested.

CORN EARS

The results of detailed ear examinations previous to time of harvesting have been found inaccurate unless such ears have been removed from the plants and the husks either partially or wholly removed, as ears were often found infested by larvae entering between the layers of husk at the tips or through the shanks. For this reason, immature ears were examined only in order to note the progress of ear infestation in any one field during the season. Whenever possible, final records in regard to the ears were made at the time of maturity. In the case of sweet corn, such counts were made either in the field at the time of picking or at a canning factory. At the factory it was possible to inspect ears of sweet corn as they passed the observer on an endless belt leading from the mechanical huskers. In order to avoid the selection of any particular ear the observer faced away from the endless belt and picked up the first ear that came in contact with his hand. Ears of hard corn (dent varieties) were examined both in the field at maturity and in the corncrib. In examining ears at the time of harvest, ears were selected by the same method as that used in selecting stalks for examination, an equal number of ears being carefully examined in the center of each quarter and in the center of the field. The first ear in each quarter was selected at random and the others taken consecutively. In order to obtain accurate information, it was necessary to remove the ears from the stalks. Many farmers objected to this practice, and for that reason the number of ears examined from each field was usually much smaller than the corresponding number of stalks. In taking a sample of ears from a corncrib the observer dug into the corn at each end and at the center of the crib, taking random ears from various locations. Whenever an ear was to be added to the sample the observer looked in another direction and picked up the first ear that touched his hand.

PROGRESS OF INFESTATION, 1920 TO 1929

1920 TO 1923, INCLUSIVE

1920

As previously stated, the laboratory was established at Silver Creek, N. Y., in 1920, and the field observations made during the years 1920 and 1921 were general in character. A survey was made in the vicinity of Silver Creek in 1920 to determine as accurately as possible the extent and seriousness of the infestation then existing in the western New York area. The results of this preliminary survey indicated the presence of a serious infestation extending over an area of approximately 25 square miles and including 700 acres of corn. Practically all of this area was included in Hanover Town, Chautauqua County. The size of the area involved and the clean-up campaign conducted throughout this area in the fall of 1920 and spring of 1921 prevented the making of complete detailed counts during these two years, except in representative fields selected at random throughout this area. For this reason it was found impossible to combine the records made in these two years in tabular form, as the results would not be comparable to the very detailed data obtained in subsequent years. Therefore, records of infestation made in 1920 and 1921 are complete only for a small number of fields over a restricted area.

In 1920 a maximum of 45 per cent of the plants were found infested in one quarter of an acre of early planted sweet corn, while the average of plant infestation in 10 average-sized fields was 21 per cent. Invariably the earlier plantings were more heavily infested than the midseason or late-season plantings. Practically no damage to ears in either sweet or dent varieties was found. A maximum stubble infestation of 12.5 per cent was observed in a 3-acre field.

1921

In 1921 a total of 27 representative fields were selected, although complete details were obtained from only 8. These fields comprised varieties of sweet and field corn; they were selected at random over an area which extended slightly beyond the limits of that of the preceding year and included a large part of the Cattaraugus Indian Reservation. A total of 5,550 plants examined showed 30.8 per cent infested, the average number of larvae per infested plant being 2.1, with an average of 65 borers per 100 plants. Both noninfested and infested plants were included, which is true throughout the following pages, unless otherwise stated, wherever the number of borers per 100 plants or stubs is given. Eight thousand stubs examined in the same fields showed an infestation of 10.62 per cent, with an average of 1.32 borers per infested stub. The stubs ranged in height from 4 to 8 inches, the average being approximately 6 inches.

There was practically no infestation in or damage to ears in 1921. Two small plots of early planted Golden Bantam sweet corn, however, showed a maximum of 14 per cent infestation, with 16.6 per cent of the kernels damaged. These were exceptional cases, an examination of 1,400 ears from representative fields showing slightly over 1 per cent to be infested.

1922

Practically the same fields were used for observation in 1922 as in 1921, although nearly twice as many plants were examined for infestation. A decided decrease was noted, both in the number of plants infested and in the larval population. The percentage of plants infested decreased from 30 to 18, while the number of borers per 100 plants decreased from 65 to 33, in a detailed survey of 14 representative fields. This decrease was undoubtedly caused by conditions existing in 1922 which were less favorable to the borer than in 1921, when an abnormal increase occurred.

The stubble infestation in 1922, based upon the examination of 9,700 stubs in 19 fields, was 5.38 per cent, as compared to 10.62 per cent infested the previous year. The infested stubble contained an average of 1.09 larvae, a decided decrease from 1921 when the infested stubble contained an average of 1.32 larvae. The average height of stubble in 1922 was approximately 7 inches, a slight increase over that in 1921. Although but 3 per cent of the ears of sweet corn were found damaged, a local canning factory reported a loss of $66.20 during the packing season due to additional cost of inspection at the sorting tables. Ears of field varieties were found to be approximately 1 per cent infested.

1923

In 1923 observations were made in 30 fields. The percentage of stalks infested dropped from approximately 18 to 15, and the number of larvae per infested plant was reduced from 1.7 to 1.3. These changes resulted in a decrease in population from 33 to 19 larvae per 100 plants. This decrease amounted to approximately 40 per cent of the 1922 infestation. This rather decided decrease was undoubtedly the result of natural conditions existing in 1923, although it is quite possible that the effect of the educational phase of the 1921 clean-up campaign was carried over to 1923 and that many farmers made an extra effort to destroy infested material.

Observations of stubble made in 27 fields during the 1923 season indicated that there was an increase in larval population of approximately 30 per cent over that of the previous year. Observations made at the same time to determine the height of stubble indicated that the average height was approximately 10 inches as compared to 7 inches in 1922. Other factors being equal, this increased height of stubble would naturally result in a decided increase in larval population. The ear infestation in 1923, based upon examinations of 11,650 ears of sweet and field corn, was 5.5 per cent as compared with 3 per cent in 1922. The commercial damage to ears in 1923, however, was comparatively slight, although it was necessary to discard occasional ears at the canning factory.

1924 TO 1929, INCLUSIVE

PLANT INFESTATION

Inasmuch as the field records made during the years 1924 to 1929, inclusive, were in greater detail than similar records made in previous years, and as the plan of making such surveys during this earlier period was somewhat enlarged upon, yearly detailed data in tabular

form were kept for this later period, primarily as a means of comparison of infestation in the same fields over this period of years.

Since 1924 the field examinations have been made each year in the same fields observed in 1924, or in near-by fields, additional fields being added as the heavily infested area increased. Field observations were necessarily discontinued in some cases where no corn was grown, either on the original or adjacent fields.

A summary of the data for the period (1922 to 1929) is presented in Table 1.

TABLE 1.—*Summary showing progress of infestation in entire plants of field and and sweet corn, Silver Creek, N. Y., 1922 to 1929, inclusive*

Year	Fields examined	Area of fields	Plants infested	Larvae per infested plant	Larvae per 100 plants [1]	Plants infested in most heavily infested field	Increase (+) or decrease (−) in larval population
	Number	*Acres*	*Per cent*	*Number*	*Number*	*Per cent*	*Per cent*
1922	14	79	18.90	1.76	33.26	40.4	
1923	30	167	15.16	1.30	19.71	61.0	−40.74
1924	36	223	26.33	2.59	68.19	76.0	+245.97
1925	44	195	40.66	2.16	87.82	83.6	+28.79
1926	53	219	66.80	3.63	242.48	98.6	+176.11
1927	56	218	42.27	4.67	197.40	96.5	−18.59
1928	46	148.87	44.29	3.02	133.75	80.0	−32.24
1929	61	210	24.01	3.01	72.27	82.0	−45.97

[1] Includes noninfested as well as infested plants.

The records show a decided progressive increase in plant infestation and borer population during 1924, 1925, and 1926. During this period the larval population increased from 68 to 242 borers per 100 plants (noninfested as well as infested plants included). In addition to the consistent increase in the percentage of plants infested, the number of borers per infested plant became greater. The increases in the percentage of plants infested indicated that the number of borers present was steadily becoming larger, but in order to substantiate this belief it was necessary to ascertain the increases or decreases from year to year in the number of borers actually inhabiting the infested plants. It was found that the number of borers per plant increased from year to year at a rate which corresponded very closely with the annual increases in the percentage of stalks infested. The two factors, percentage of infestation and number of borers per infested plant, which were used in determining larval population, varied from day to day during each season, owing to the migration of larvae from infested to noninfested plants, but the borer population in each field necessarily remained constant during the entire season.

The several varieties of corn represented in the fields selected for observation are commonly planted in the western New York area. The predominating varieties of sweet corn planted in the section where the observations were made are Evergreen and Golden Bantam, whereas Leaming and White Cap dent are the most common field varieties. The information obtained does not indicate that any particular type or variety of corn is noticeably more resistant or more susceptible to the borer.

The damage to sweet-corn varieties is usually more noticeable than the damage to field-corn varieties because the stalks of the latter are larger and more rigid and can withstand the work of a greater number of borers. Fields of Golden Bantam corn often appear to be very heavily infested because the tunnels made by the borers weaken the tender stalks to such an extent that the stalks are easily broken down by strong winds and heavy rains.

The information obtained does not indicate that the size of the field has any connection with the degree of infestation, except that very small garden patches were usually more heavily infested than fields covering one-half acre or more. These small garden patches are usually planted earlier than larger fields, and the plants are large enough during the oviposition period to be particularly attractive to corn-borer adults. The proximity of such small plantings to barnyards, where accumulations of infested material are often found, may account, in part, for the severe infestations usually found in garden patches.

A marked decrease in larval population occurred in these same fields in 1927, when the intensity of infestation dropped to 197 larvae per 100 plants. This decrease from 242 to 197 larvae per 100 plants indicates the effectiveness of the control measures in the clean-up campaign conducted in 1927, especially since increases occurred in the adjacent area where no complete control measures were practiced.

Since 1927 the infestation has decreased steadily in practically the entire western New York area, the only exceptions being those sections where favorable weather conditions have prevailed. Low temperature and lack of precipitation during the spring months have reduced the flight of moths, thereby diminishing the number of eggs deposited. Extremely warm and dry weather in July of each year interfered with the hatching of eggs, and the same conditions made it impossible for many young larvae to become established. The progress of infestation during this period is indicated in Table 1.

In order to compare the plant infestation in dent and sweet-corn types during the period of years 1924 to 1929, an analysis of the yearly count tables was made, and the results for the two types are shown in Table 2. As practically no flint varieties were grown in this area, they have necessarily been omitted.

TABLE 2.—*Summary showing comparison of yearly infestation in commercial plantings of field and sweet corn, Silver Creek, N. Y., 1924 to 1929, inclusive*

Year	Field corn (dent)					Sweet corn				
	Fields examined	Area	Plants infested	Larvae per infested plant	Larvae per 100 plants [1]	Fields examined	Area	Plants infested	Larvae per infested plant	Larvae per 100 plants [1]
	Number	*Acres*	*Per cent*	*Number*	*Number*	*Number*	*Acres*	*Per cent*	*Number*	*Number*
1924	27	176.00	28.46	2.50	71.15	9	47.00	25.34	2.82	71.46
1925	29	139.87	36.50	1.94	70.81	15	55.00	46.15	2.14	98.76
1926	29	170.50	64.88	3.17	205.75	24	48.25	71.03	4.57	324.61
1927	40	188.50	40.80	4.38	178.70	16	29.00	49.40	5.90	291.46
1928	32	128.50	42.60	2.46	104.79	14	20.37	55.10	5.75	316.82
1929	36	153.25	19.65	2.14	42.05	25	56.75	33.44	4.10	137.10

[1] Includes noninfested as well as infested plants.

The data presented in Table 2 indicate the increase in intensity of infestation in both types of corn during the period 1924 to 1926, inclusive. During this period the larval population in field corn

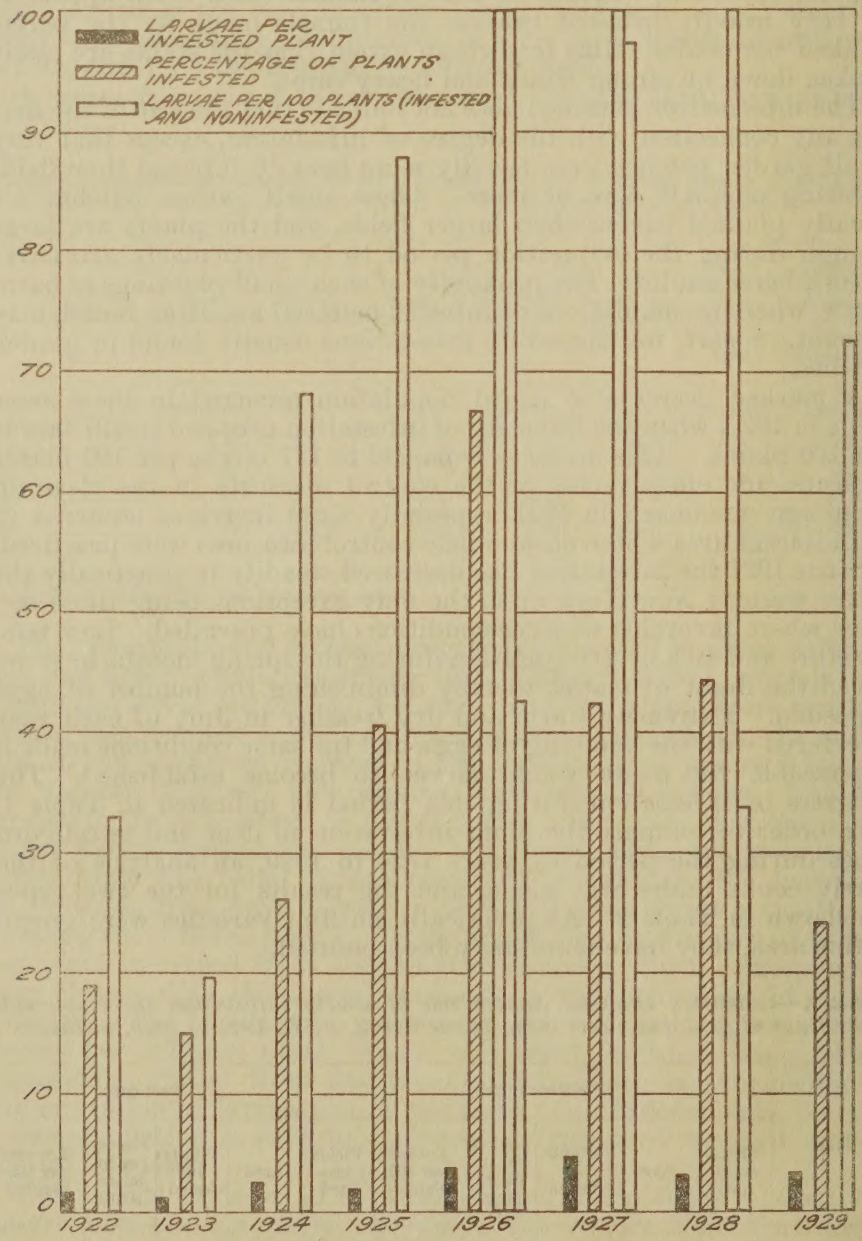

FIGURE 1.—Percentage of plants infested, number of larvae per infested plant, and number of larvae per 100 plants, Silver Creek, N. Y., 1922 to 1929, inclusive

increased from 71 to 206 larvae per 100 plants, and in sweet corn from 71 to 325 larvae per 100 plants. This increase was greater in sweet corn than in field varieties, and it indicated that sweet corn

was more attractive to the borer than field corn, which in reality is not true. In general, sweet corn is planted earlier than field corn, and the plants of the former are larger when eggs are deposited by corn-borer adults. The moths invariably select plants of fair size for egg deposition in preference to very small ones. The infestation in both types of corn decreased decidedly in 1927 as a result of the clean-up campaign conducted during that year. Additional decreases have occurred in 1928 and 1929, and during the latter year the infestation in field corn dropped to approximately 42 larvae per 100 plants. During the same period the infestation in sweet corn has also decreased, although the rate of infestation has not yet reached the 1924 level.

Whenever possible, complete infestation records were made in detail of corn stubble and ears in those same fields where observations were made of entire plants, in order to complete the history of development of infestation in such fields over a series of years.

Table 1 and Figure 1 indicate in summary form the average progress of plant infestation during the 8-year period from 1922 to 1929, inclusive, in the same or near-by fields in this area. In general, the increase was steady and decided during the period 1922 to 1926, inclusive, the increase for this period being approximately 630 per cent over the 1922 infestation. The maximum was reached in 1926, when the population in all types of corn amounted to 242 larvae per 100 plants. The decrease in 1927 was a result of the clean-up campaign conducted during that year, and similar decreases in 1928 and 1929 may have resulted in part, either directly or indirectly, from the same clean-up operations.

INFESTATION IN CORN STUBBLE

Up to this point, in discussing the progress of infestation during the period 1924 to 1929, reference has been made to corn borer infestation in the entire corn plant, yet similar increases and decreases occurred in corn stubble and ears, which are discussed in the following paragraphs. The importance of corn stubble as a source of reinfestation is generally appreciated, and is discussed at length in publications by Worthley and Caffrey.[3]

In general, the stubble in early planted fields was more heavily infested than that in fields which were planted later, although the height of stubble and the time the stalks were cut were the important determining factors governing borer population in stubble. Many fields of sweet and silage corn were cut early in the season at a time when most of the larvae were in the upper portions of the stalks and comparatively few were left in the stubble.

Table 3 and Figure 2 present summaries of the data obtained from the examinations of stubble during the period 1922 to 1929, inclusive.

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[3] Caffrey, D. J., and Worthley, L. H. Op. cit. (U. S. Dept. Agr. Bul. 1476: 95–97.) See footnote 2.

——— and Worthley, L. H. The European corn borer—its present status and methods of control. U. S. Dept. Agr. Farmers' Bul. 1548: 40. 1927.

Worthley, L. H., and Caffrey, D. J. Op. cit. (U. S. Dept. Agr. Misc. Circ. 104: 6.) See footnote 2.

——— and Caffrey, D. J. Op. cit. (U. S. Dept. Agr. Tech. Bul. 53: 83.) See footnote 2.

TABLE 3.—*Summary showing degree of stubble infestation in commercial plantings of field and sweet corn in the vicinity of Silver Creek, N. Y., 1922 to 1929, inclusive*

Year	Fields examined	Area of fields	Stubble infested	Larvae per infested stub	Larvae per 100 stubs [1]	Stubble infested in most heavily infested field	Increase (+) or decrease (−) in larval population
	Number	*Acres*	*Per cent*	*Number*	*Number*	*Per cent*	*Per cent*
1922	19	89	5.38	1.09	5.86	10.2	
1923	27	150	7.30	1.05	7.66	56.0	+30.71
1924	36	223	10.17	1.11	11.26	38.0	+46.99
1925	36	164.5	12.16	1.08	13.13	72.0	+16.60
1926	[2] 9	49.5	43.03	1.18	50.86	73.0	+287.35
1927	38	152.75	13.76	1.12	15.37	88.5	−69.77
1928	37	132.37	12.67	1.08	13.72	36.0	−10.74
1929	43	150.5	6.75	1.10	7.41	50.0	−46.00

[1] Includes noninfested as well as infested stubble.
[2] Few fields cut because of wet weather.

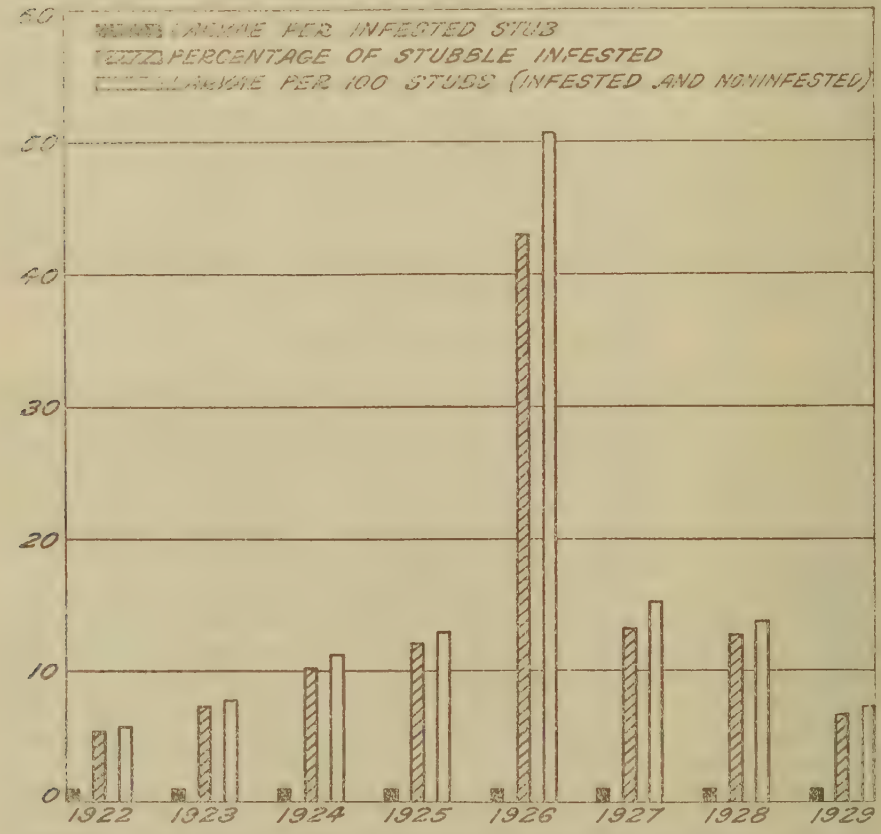

FIGURE 2.—Percentage of stubble infested, number of larvae per infested stub, and number of larvae per 100 stubs, Silver Creek, N. Y., 1922 to 1929, inclusive

The summary in Table 3 indicates the constant increase in stubble infestation from 1922 to 1926, at which time the borer population reached 50 larvae per 100 stubs. Since 1926 the decrease has been constant, although the stubble infestation in 1929 had not declined to the level of 1922; i. e., 5.86 per cent in 1922 and 7.41 per cent in

1929. In general, the increases and decreases in stubble infestation have been similar to the changes occurring in stalk infestation. A comparison of the larval content in corn stubble over a series of years is not, however, entirely dependable, as the time and height of cutting greatly influence the density of larval population. The number of borers per infested stub has remained practically constant from year to year during the entire period in which surveys have been made, the large increase in borer population resulting from the increasing numbers of stubs infested. The maximum stubble infestation occurred in 1926. The decrease in 1927 was caused directly by the clean-up campaign conducted in western New York during the spring of that year, as the usual increase in stubble infestation was noticed in adjacent areas where no thorough clean-up operations were conducted. The decreases occurring in 1928 and 1929 correspond with similar decreases in stalk infestation and may have been the direct or indirect result of the 1927 clean-up campaign.

DEGREE OF INFESTATION IN STUBBLE

In order to determine the relative importance of various factors influencing the larval population left in stubble, an experiment was conducted in which corn was cut by hand, at various measured heights and at regular intervals, during the late summer and fall of 1925. This experiment in a field of heavily infested Golden Bantam sweet corn near the laboratory at Silver Creek was started on August 25, 1925, new cuttings and examinations being made at 10-day intervals whenever possible. The last examination was made on October 5. Previous to each cutting, the average number of larvae per 100 plants was carefully determined. Dead larvae and those killed while cutting stalks at various heights from the ground were not included in the number recovered from remaining stubble. In all cases 100 consecutive plants were used which were adjacent to those in which the larval population had been determined. The results are given in Table 4.

TABLE 4.—*Infestation in corn stubble cut at various heights and over a period of several weeks, Silver Creek, N. Y., 1925*

Date	Estimated number of larvae per 100 plants	Number of larvae recovered per 100 stubs of specified heights								
		1 inch	2 inches	3 inches	4 inches	5 inches	6 inches	8 inches	10 inches	12 inches
Aug. 25	164	1	5	10	15	27	34	35	50	54
Sept. 4	158	14	32	31	38	51	58	50	97	134
Sept. 14	161	3	28	23	34	65	76	60	105	64
Sept. 24	143	9	27	37	67	63	55	90	108	114
Oct. 5	98	4	31	20	42	57	55	62	105	91
		Percentage of estimated total of larvae remaining in stubble of specified heights								
Aug. 25	164	0.61	3.04	6.09	9.15	16.46	20.73	21.34	30.49	32.93
Sept. 4	158	8.86	20.25	19.62	24.05	32.27	36.70	31.64	61.39	84.81
Sept. 14	161	1.86	17.39	14.28	21.12	40.37	47.20	37.26	65.22	39.75
Sept. 24	143	6.29	18.88	25.87	46.85	44.05	38.46	62.93	75.52	79.72
Oct. 5	98	4.08	31.63	20.40	42.85	58.16	56.12	63.26	107.14	92.85

While some variations are evident in Table 4, in general the experiment indicates that the larval population in sweet-corn stubble resulting from the cutting of stalks in early October is approximately two or three times greater than the larval content in stubble remaining after cutting in late August. The larval population remaining in 12-inch stubble was approximately ten times greater than that in 1-inch stubble. These data clearly indicate the necessity for low, early cutting. The short stubble also is more easily plowed under and leaves less surface débris in which migrating larvae can hibernate after the land is prepared for planting.

INFESTATION IN CORN EARS

Corn is an important crop in the Silver Creek section, large acreages of sweet varieties being planted for canning and table use, as well as varieties of dent corn for feeding. Only occasionally are any varieties of flint corn grown. Notwithstanding the gradual increase in the number of ears infested during the earlier surveys, no alarming ear infestation or kernel damage occurred until 1925. This increase in ear infestation, although gradual in this earlier period, indicated that serious ear and kernel damage might be anticipated in later years, if the infestation should continue to increase.

The summary report in Table 5 includes not only records of ears from these particular fields, but also other ears examined in fields and at canning factories throughout this area.

TABLE 5.—*Infestation in ears of field and sweet corn in the western New York area, 1921 to 1929, inclusive*

[These records include ears examined at canning factories as well as in the field]

Year	Ears examined	Ears infested	Percentage increase (+) or decrease (−)	Year	Ears examined	Ears infested	Percentage increase (+) or decrease (−)
	Number	*Per cent*			*Number*	*Per cent*	
1921	1,400	1.50		1926	13,395	25.43	+119.0
1922	10,182	2.80	+86.6	1927	11,130	15.30	−39.8
1923	11,650	5.50	+96.4	1928	4,600	13.91	−9.1
1924	12,000	9.04	+64.3	1929	4,458	6.62	−52.4
1925	18,875	11.61	+28.4				

CANNING FACTORIES

Because of the establishment of canning factories in the Silver Creek section and the adaptability of the corn plant to soil and farming conditions in this particular section, the sweet-corn crop is an important one. Three factories are situated in the immediate vicinity, all of which process sweet corn in large quantities and contract with growers in a comparatively large area. Early and late varieties of sweet corn are handled, principally Golden Bantam, Evergreen, and Hickox. Although partial crop losses were reported by the various canning factories prior to 1925 because of damage to sweet-corn ears by the European corn borer, in many cases definite figures expressing losses can not be given because the damage done

by the European corn borer was often confused with damage caused by other corn pests. In 1925, however, damage due exclusively to European corn-borer activities in sweet-corn ears was quite evident and losses due to such damage were generally recognized. During this season one factory reported an additional cost of $75 due entirely to corn-borer damage. Similar reports were received from other corn-processing companies.

In 1926 the infestation in sweet-corn ears increased from 14.08 per cent the previous year to 24.9 per cent, and during this year maximum damage and infestation in processing ears was recorded. The largest factory reported further increased costs occasioned by the employment of additional inspectors in the field, as well as added labor at the sorting and cutting tables, and that during the entire sweet-corn picking season an average of 12 women in excess of the usual number were employed in the removal of larvae and damaged kernels. The presence of larvae in the ears necessitated the purchase and installation of especially designed cleaning and washing equipment.

In 1927 the general decrease in infestation was very noticeable in ears, the percentage of ears infested decreasing from 24.9 to 6.6, with practically no commercial damage in canning-factory ears. However, very early sweet corn was badly damaged in many cases, records from one field of Golden Bantam corn indicating that 74 per cent of the ears contained borers. During the 1927 season only two factories packed corn, and for this reason the number of ears inspected was smaller than in previous years. The packing of corn at one factory was discontinued in 1927, primarily because of unfavorable conditions in the canning business, although the presence of corn-borer infestation in ears of sweet corn was a factor considered by the canners in deciding to discontinue the packing of corn. In 1928 a second factory discontinued the packing of corn, and records were made during 1928 and 1929 at only one factory.

A decided decrease in ear infestation occurred in 1928, when examinations conducted at one canning factory indicated that approximately 1 per cent of the ears were infested. No commercial loss occurred during this season, and infested ears were removed by the usual force of inspectors. In 1929 the degree of infestation in sweet-corn ears, based upon observations of 3,450 ears, increased from 1.03 per cent to 1.65 per cent. This figure, however, is misleading and does not represent average conditions in this section. It will be noted that the most severe infestation found at the canning factory in 1928 amounted to 2 per cent, whereas a similar figure in 1929 was 18 per cent. This figure represents an unusually severe infestation, and if it be excluded from the records the 1929 average falls slightly below that of 1928. The results of examinations of sweet-corn ears at canning factories are summarized in Table 6.

TABLE 6.—*Summary showing degree of infestation in ears of sweet corn at canning factories, Silver Creek, N. Y., 1925 to 1929, inclusive*

Year	Ears examined	Ears infested		Ears infested in most heavily infested field	Percentage increase (+) or decrease (−) in ear infestation
	Number	*Number*	*Per cent*	*Per cent*	
1925	9,550	1,345	14.08	43.5	
1926	11,508	2,875	24.98	82.0	+77.4
1927	7,550	498	6.60	54.0	−73.6
1928	1,650	17	1.03	2.0	−84.4
1929	3,450	57	1.65	18.0	+60.2

REFUSE FROM CANNING FACTORIES AS A SOURCE OF REINFESTATION

Several methods of disposing of cobs and husks are practiced by canners, and it has been found that a comparatively large quantity of such material containing European corn-borer larvae is returned to farms where it is used as feed or fertilizer. Some factories are equipped with silos which make possible the destruction of practically 100 per cent of all borers, while at other factories the material is placed in piles and allowed to heat, a practice which destroys many but not all borers. The method, however, which is to be most condemned consists of selling such waste material to farmers as soon as it leaves the factory, because such material usually reaches the barnyard or feed lot, where many of the borers survive.[4]

SEASONAL PLANTING

The records from experimental plots, as well as observations and records made in commercial fields, show that infestation and damage to both sweet and field varieties are very closely correlated with the time of planting. In the Silver Creek area the insect usually starts pupation in early June, and adults begin to appear in the field in late June and are present until the middle of August.

During the seasons of 1926 to 1929, inclusive, representative commercial fields of sweet and dent corn were observed and infestation records made. The records of these fields were grouped into separate periods, depending upon the planting dates. (Table 7.) The records obtained were similar to previous laboratory and field observations and indicated that infestation and damage to both sweet and field corn decreased when plantings were delayed until June 1, and that even later plantings showed little or no commercial damage. In order to obtain marketable sweet-corn ears for early market, it is necessary to plant corn in this area during the first week in April. Such fields usually show slightly less infestation than fields planted on or about April 15. It is quite probable that the plants produced by these extremely early plantings are so large by the time the oviposition period arrives that they are less attractive to corn-borer adults than those in fields which are planted at a later date, although it is evident that the moths prefer fairly well developed plants on which to deposit their eggs.

[4] CAFFREY, D. J., and WORTHLEY, L. H. Op. cit. (U. S. Dept. Agr. Bul. 1476: 119.) See footnote 2.

TABLE 7.—*Degree of infestation in entire plants of sweet and field corn as affected by date of planting in the Silver Creek (N. Y.) area, 1926–1929*

Year	Sweet corn					Field corn				
	Planting period	Fields	Plants	Larvae in plants	Larvae per plant	Planting period	Fields	Plants	Larvae in plants	Larvae per plant
1926	Apr. 7 to 23	2	12,616	51,304	4.07	May 10 to 21	7	433,613	1,007,934	2.32
	Apr. 24 to May 11.	3	25,418	122,428	4.81	May 22 to June 2	14	639,385	1,744,001	2.72
	May 12 to 27	11	297,524	1,119,354	3.76	June 3 to 13	7	352,496	332,502	.94
	May 28 to June 11.	8	347,567	924,887	2.66	June 14 to 23	1	84,500	22,511	.26
1927	Apr. 7 to 23	2	68,212	335,105	4.91	May 10 to 21	9	182,530	189,286	1.03
	Apr. 24 to May 11.	2	13,977	74,376	5.32	May 22 to June 2	7	262,361	1,119,072	4.26
	May 12 to 27	4	62,238	235,787	3.78	June 3 to 13	9	508,219	710,331	1.39
	May 28 to June 11.	7	170,021	278,164	1.63	June 14 to 23	14	699,757	952,729	1.36
	June 12 to 20	1	2,396	2,644	1.10	June 24 to July 1	1	5,355	2,811	.52
1928	Apr. 24 to May 11.	7	148,554	470,321	3.16	May 10 to 21	6	598,864	586,580	.98
	May 12 to 27	4	65,150	269,994	4.14	May 22 to June 2	23	941,088	1,073,348	1.14
	May 28 to June 11	3	37,392	56,430	1.51	June 3 to 13	3	72,404	35,219	.49
1929	Apr. 24 to May 11.	8	194,741	594,096	3.05	May 10 to 21	4	129,675	176,633	1.36
	May 12 to 27	3	115,388	196,344	1.70	May 22 to June 2	9	568,288	294,269	.52
	May 28 to June 11.	10	384,130	322,963	.84	June 3 to 13	10	434,173	199,479	.46
	June 12 to 20	4	139,521	30,740	.22	June 14 to 23	10	539,414	73,386	.14
						June 24 to July 1	3	131,379	15,516	.12

From a commercial standpoint, however, it is advisable for early sweet-corn growers to delay planting in order to avoid maximum infestation, and the later planting of field corn, and of sweet corn for canning, is strongly recommended, although planting should occur early enough to insure the maturity of the crop. Delayed plantings in lightly infested areas in western New York, however, are not recommended inasmuch as reductions in yields may result. Experiments conducted in 1926 showed that standard varieties of sweet corn matured well in western New York when planted as late as June 17, while early maturing field varieties could not be planted later than June 3 and produce a mature crop.

Trap crops apparently have proved successful in some cases, but in general they have been found of little value. They should in all cases be promptly destroyed, as otherwise they may provide infestation for later crops.

ESTABLISHMENT OF LARVAE

Efforts were made during the seasons of 1926 and 1927 to determine the percentage of corn-borer eggs which hatch and produce full-fed larvae. The records obtained are not entirely reliable, as many unavoidable influences were encountered which may materially effect final results. Establishment varies somewhat in the several types and varieties of corn and the stage of its growth at the time of egg hatching. Of the various methods at first used, all artificial methods of infesting plants under observation were, whenever pos-

sible, discarded as impractical, and conditions were made as near natural as possible.

In conducting this experiment, representative fields of sweet and field corn, planted on various dates, were selected in the lightly infested area. In each field, widely separated hills were selected upon which caged adults were allowed to deposit eggs. The cages were then removed and the adults killed. The total number of eggs deposited by the caged females were counted, the locations of egg masses recorded, and the hills tagged for identification. Examinations of all plants within 25 feet of the infested hills were made every three days for egg masses laid by free adults during the oviposition period. Any such masses found were destroyed and only those deposited by caged adults allowed to remain. After the surviving larvae became full-fed, all plants in this area were dissected and the percentage of larval survival obtained.

No definite conclusions can be drawn at this time relative to the rate of larval survival and establishment, owing to the many affecting factors which must be considered, and because such an experiment must be conducted over a series of years. Results obtained during this short period indicate a larval survival of approximately 15 full-fed larvae from every 100 eggs laid, and that survival is slightly higher in sweet-corn, in comparison with field-corn varieties, when both types are considered at the same stage of growth. As already stated, these are not conclusions and apply only to a 2-year period during which observations have been made.

Further observations have been made to determine the survival and establishment of larvae from egg masses which have become dislodged from the corn plant and have fallen to the ground. Egg masses in various stages of development were dropped to the ground at distances ranging from 6 to 8 inches from uninfested corn plants. Such plants and surrounding plants were kept free from other infestation. Dissections of plants were made after the larvae reached maturity, and the resulting establishment percentages were recorded. Results indicate that under such average conditions only about 6 borers from every 100 eggs dislodged were able to survive to maturity.

HOST PLANTS

Although corn is the only crop grown in the western New York area in which commercial damage has occurred, several other crops and many species of large-stemmed weeds have been found infested. With but few exceptions, all such plants have been found infested only when growing in or adjacent to infested cornfields, such infestation evidently resulting from migration. Infestation in such weeds increased rapidly during the period from 1920 to 1926, and at that time examinations made in barnyard grass, cocklebur, pigweed, lamb's-quarters, panic grass, and foxtail, growing in close proximity to heavily infested corn, showed that from 20 to 96 per cent of such plants were infested and that the larval population per 100 plants ranged from 20 to 730.

The heavy infestation which may be carried over in weeds, therefore, must be considered as a serious problem, and such weed areas as well as the adjacent corn plants must be destroyed if infestation

is to be controlled. During the season of 1927, however, decided decreases in weed infestation were apparent, due primarily to the burning of such areas during the clean-up campaign conducted in the spring of that year. In 1928 and 1929 additional decreases in weed infestation, corresponding to similar decreases in corn infestation, occurred.

A complete list of host plants found to be infested by the European corn borer in the western New York area during the period 1920 to 1929 is given below. This list includes many plants in which very slight infestations were found.

HOST PLANTS LISTED IN WESTERN NEW YORK, 1920–1929

Aster (*Aster* spp.)[5]
Bachelor's button (*Centaurea syanus* L.)[5]
Barnyard grass (*Echinochloa crus-galli* (L.) Beauv.)
Bean (*Phaseolus* spp.)
Begger-ticks (*Bidens* spp.)
Blackberry (*Rubus* sp.)
Broomcorn (*Holcus sorghum* L.)
Buckwheat (*Fagopyrum vulgare* Hill)
Burdock (*Arctium* spp.)
Calendula (*Calendula officinalis* L.)[5]
Charlock (*Brassica arvensis* (L.) Ktze.)
Chrysanthemum (*Chrysanthemum* spp.)[5]
Cocklebur (*Xanthium* spp.)
Coltsfoot (*Tussilago farfara* L.)
Concord grape (horticultural variety of *Vitis labrusca* L.)
Corn (flint, dent, pop, sweet) (*Zea mays* L.)
Cosmos (*Cosmos bipinnatus* Cav.)[5]
Cowpea (*Vigna sinensis* (L.) Endl.)[5]
Dahlia (*Dahlia* spp.)
Dock (*Rumex* spp.)
Foxtail (*Chaetochloa* sp.)
Goldenrod (*Solidago* spp.)
Ground cherry (*Physalis* sp.)
Lamb's-quarters (*Chenopodium album* L.)
Millet, German (*Echinochloa italica* L.)
Millet, Japanese (*Echinochloa crus-galli edulis* Hitchc.)
Milo (horticultural variety of *Holcus sorghum* L.)
Nightshade (*Solanum nigrum* L.)
Panic grass (*Panicum* sp.)
Pigweed (*Amaranthus retroflexus* L.)
Pokeberry (*Phytolacca americana* L.)
Potato (*Solanum tuberosum* L.)[5]
Ragweed (*Ambrosia* spp.)
Rhubarb (*Rheum rhaponticum* L.)[5]
Sedge (chufa) (*Cyperus esculentus* L.)
Smartweed (*Polygonum* spp.)
Sorghum (*Holcus* spp.)[5]
Soybean (*Soja max* (L.) Piper)
Squash (*Cucurbita maxima* Duchesne)
Sudan grass (*Holcus sorghum sudanensis* (Piper) Hitchc.)[5]
Sunflower (*Helianthus* spp.)
Thistle (*Cirsium* sp.)
Tomato (*Lycopersicon esculentum* Mill.)
Velvetleaf (*Abutilon theophrasti* Medic.)
Water cress (*Radicula* sp.)
White Siberian proso (*Panicum miliaceum* L.)[5]

[5] Plants found infested only in experimental plots.

SUMMARY AND CONCLUSIONS

In order to determine the progress of infestation by the European corn borer in western New York from 1920 to 1929, inclusive, yearly observations were made in representative cornfields located in Westfield, Portland, Pomfret, Sheridan, Dunkirk, and Hanover Towns in Chautauqua County and Brant Town in Erie County. The results of these observations apply to the territory in which the observations were made and are not necessarily applicable to other infested areas.

The earlier observations were made primarily to determine the extent and seriousness of the infestation in the western New York area, while later observations were intended to supply information to interested persons concerning the progress of the infestation. The early observations showed no severe damage in western New York, but the fact that other areas had experienced severe damage indicated that the infestation in western New York might become serious enough to interfere with the production of corn, which is an important crop in this area. When first discovered in 1919, the insect was infesting an area of approximately 25 square miles in the vicinity of Silver Creek, Chautauqua County. On July 1, 1920, there were 469 square miles of infested territory in the area bordering Lake Erie. Not only had the insect spread to new territory, but the original infestation in Chautauqua County had become more severe. In 1926 practically the whole of New York State and one-half of Pennsylvania had become infested.

Observations were made in ears, stubble, and entire plants. Most of the observations of ears were made at canning factories, although it was often possible to examine small numbers of ears in the field. Whenever possible, the sample used in estimating the degree of plant infestation in a field amounted to 100 plants per acre, but the minimum in any one field was 100 plants and the maximum, 500 plants, equal numbers of consecutive plants being taken in the center of each quarter and in the center of the field. The same method of selection was used in making stubble observations.

The 1920 infestation was comparatively light, and no commercial damage was noted. The most severe infestation was found in a small field of early planted sweet corn, where 45 per cent of the plants were found to be infested. The maximum stubble infestation in 1921 was 12½ per cent. After 1921 the degree of infestation increased steadily until 1926, when approximately 67 per cent of the plants in the area under observation were infested. At this time the average infested plant contained 3.6 larvae. During the period prior to 1927 the degree of infestation increased from 65 larvae per 100 plants in 1921 to 242 larvae per 100 plants in 1926. No general commercial damage occurred prior to 1926, although reports from individuals in 1924 and 1925 indicated isolated cases of commercial damage. In 1926 commercial damage was general, and it was necessary for canning factories to employ special field inspectors and additional helpers at the sorting tables. It was also necessary in 1926 to use special machinery in treating infested ears.

In 1927 the United States Department of Agriculture, in cooperation with the New York State Department of Agriculture, conducted an intensive clean-up campaign in the severely infested portions of

New York State. This clean-up area included the town in which the field observations had been made during previous years. As a result of this clean-up campaign, the 1927 infestation dropped to approximately 197 larvae per 100 plants, as compared with 242 larvae per 100 plants in 1926. The decrease in ear infestation was also noticeable in 1927, there being approximately 15 per cent infested as compared to 25 per cent in 1926. Since 1927 the infestation decreased steadily until 1929, when the plant infestation amounted to approximately 72 larvae per 100 plants. The ear infestation also decreased during the period 1927 to 1929, inclusive, and in 1929 approximately 6.6 per cent of all ears were found to be infested.

The results of the observations do not indicate that any type or variety of corn is particularly susceptible to corn-borer attack. It is evident, however, that early planted corn, regardless of the type and variety, is more severely attacked than corn planted during late May and early June. The more severe infestation occurring in sweet-corn varieties was thought at first to indicate that this type of corn was more susceptible to corn-borer attack than varieties of field corn. It became apparent later, however, that the more severe infestation in sweet varieties resulted from the fact that sweet corn is usually planted earlier than other corn. Corn planted during late April and early May becomes sufficiently matured in July as to be particularly attractive to corn-borer adults. The plants of later planted corn are smaller and less attractive to the ovipositing female.

Preliminary observations made during 1926 and 1927 indicated that approximately 15 full-grown larvae were produced from every 100 eggs deposited. This figure varied somewhat with the type of corn and the size of the plant at the time of egg-hatching. No definite conclusions can be drawn concerning the percentage of larval survival because of many factors concerning survival which were not considered in conducting the observations during the 2-year period.

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